A MIDDLE TRIASSIC FLORA FROM THE CACHEUTA FORMATION, MINAS DE PETROLEO, ARGENTINA

by R. K. JAIN *and* T. DELEVORYAS

ABSTRACT. The fossil flora of the Triassic beds of Minas de Petroleo, a locality about 32 km. south-west of Mendoza in western Argentina (long. 69° 6′ 25″ W.; lat. 33° 3′ 35″ S.) is described. The strata belong to the Potrerillos Beds of the Cacheuta Formation of the Upper Gondwana of Argentina. The flora consists of about 34 species (3 new), belonging to about 20 genera (one new). Previously the flora of the Potrerillos Beds was known to consist of about 28 species. These beds were earlier referred to as the 'Rhaetic beds' and lately as of 'Lower to Middle Keuper' age, but the flora is now shown to be not younger than Middle Triassic in age.

THE fossils were collected from Minas de Petroleo in 1916–17 by the late Dr. G. R. Wieland, who never completed his study of the flora. The specimens, deposited in the Paleobotanical Collections of the Peabody Museum of Natural History at Yale University now bear official numbers referred to in the following pages. In addition to a couple of cards with collection data, there are also a few photographic negatives of some fossils, including those on which Wieland had published earlier (Wieland 1929), and two more on which he apparently had intended to report. Although the specimens in the unpublished photographs could not be located, they are being included in this paper.

STRATIGRAPHY

The Gondwanas of Argentina are divided into the Upper and Lower Gondwana. The Lower Gondwana or the 'Terreno de Paganzo' ranges from the earliest Carboniferous (perhaps with an Upper Devonian base) to the end of the Permian (Frenguelli 1950). Overlying the Patquia Formation of the Lower Gondwana are the so-called 'Rhaetic Beds' of the Upper Gondwana of Argentina (Krishnan 1954). These beds occur in the provinces of Mendoza, San Juan, La Rioja, and Patagonia, and are classified into various formations. The Cacheuta Formation of Mendoza represents one of the lowest formations in the Upper Gondwana of Argentina. Because of the existence of the so-called '*Thinnfeldia* flora' in these beds, they were earlier referred to as the 'Rhaetic beds' and later considered as 'Middle to Upper Keuper' (Groeber and Stipanicic 1952), and Middle Triassic to 'Infra-Liassic' (Frenguelli 1948). This subject is discussed further in a later part of this paper.

The Cacheuta Formation is further divided into four beds or 'Estratos':

4. Estratos de Rio Blanco
3. Estratos de Cacheuta { Upper / Lower
2. Estratos de Potrerillos
1. Estratos de la Cabras { 'Grupo del Cerro las Cabras' { Upper / Middle / Lower ; 'Fangalomerado' rojo

[Palaeontology, Vol. 10, Part 4, 1967, pp. 564–89, pls. 86–97.]

The rocks at Minas de Petroleo belong to the Potrerillos Beds (cf. Frenguelli 1944*b*, p. 557; 1948).

Minas de Petroleo is a well-known locality about 32 km. south-west of Mendoza in western Argentina (long. 69° 6′ 25″ W., lat. 33° 3′ 35″ S.). The outcrop is at the edge of an open region where the foothills rise rapidly. Wieland (1925) recognized seven zones in the 160-m. thick section rising from the Cacheuta volcanic base. Most of the plant fossils were found in laminated arenaceous to carbonaceous shales or fine clays in the second and third zones, starting from 10 m. above the volcanic base through a thickness of 70 m. Some ferns and Sphenopsida were found in a 10-m. thick zone (No. V) of shales and lesser conglomerates starting from 90 m. above the base.

Previous work. One paper by Wieland (1929) represents the only work on the plant fossils of the Triassic of Minas de Petroleo. He described some 'fruits' which he named *Fraxinopsis minor* and *F. major*, and a fragment of a leaf, which is now known as *Yabeiella wielandi* Oishi. However, much work has been done on other beds of the Cacheuta Formation. The main contributors to our knowledge of the flora of this formation were Geinitz (1876), Szajnocha (1889), Kurtz (1921), Wieland (1929), Oishi (1931), and Frenguelli (1941*a*, *c*; 1942; 1943*a*, *b*; 1944*a*, *b*, *c*, *d*; 1946; 1947; 1948; 1950). As a result of their work about 20 species are known from Estratos de la Cabras, about 27 from Estratos de Potrerillos, and about 17 from Estratos de Cacheuta (Frenguelli 1948).

Materials and methods. Most of the fossils are only impressions; some are compressions having a thin film of carbon, but no cuticle. Only one specimen (1120) yielded some fragments of cuticles; these were removed with a scalpel and transferred to a watch glass, and treated for a few minutes with 'Clorox', a commercial bleaching solution containing 5·25% sodium hypochlorite by weight in an inert ingredient. In a few minutes the material was cleared; then it was thoroughly washed. A few fragments were stained with 2% aqueous safranin, and washed to remove the excess stain. The stained as well as the unstained fragments of cuticles were mounted directly in glycerine jelly.

SYSTEMATIC DESCRIPTIONS

Division BRYOPHYTA?, Class HEPATICAE?, Order?, Family?
Genus THALLITES Walton 1925

Thallites sp.

Plate 86, figs. 1–3

Material. Two specimens (1104 *a*, *b*) measuring 1–1·5 cm. in length, and *c*. 1 mm. in width above or below the dichotomy. In both the thalli branch twice dichotomously. A mid rib is recognizable in the middle of the thallus; no other structural details are discernible. Outline of thallus indistinct, uneven.

Remarks. Because there is no indication of natural affinities the specimens are referred to the form genus *Thallites* Walton (1925), defined to accommodate thalloid forms of uncertain affinities.

Division TRACHEOPHYTA
Subdivision SPHENOPSIDA
Order EQUISETALES
Family EQUISETACEAE
Genus NEOCALAMITES Halle 1908

Neocalamites carreri (Zeill.) Halle

Plate 86, figs. 4–6

Material. Four specimens (1095–7, 1106). 1095 (Pl. 86, fig. 4) is a stem fragment *c.* 12 cm. in length, and *c.* 3·5 cm. in width. It has two nodes separated by a 7-cm. long internode, one of the nodes being more distinct than the other. The surface shows 12–16 ridges per cm., alternating with furrows. It is not clear whether or not the ridges and furrows are continuous across the nodes.

At one of the nodes of the stem in 1096 (Pl. 86, fig. 5) there is a whorl of long linear leaves which are free to the base. The exact length of the leaves is not known, but they appear to be shorter than the internode, and measure *c.* 2 mm. in width. The internode in this specimen is *c.* 4 cm. long and has no visible surface markings.

1097 (Pl. 86, fig. 6) shows a detached nodal diaphragm *c.* 3 cm. in diameter. At its periphery is a whorl of leaves of which only the teeth-like basal parts are visible; faint further extensions indicate that the leaves were rather long as in 1096 (Pl. 86, fig. 5). An apparently similar diaphragm was described by Du Toit (1927) from the Molteno beds of the Karoo System of South Africa.

Genus EQUISETITES Sternberg 1933

Equisetites fertilis Frenguelli

Plate 86, figs. 7–10

Synonymy. See Frenguelli 1944*c*, pp. 501–9, pl. 1–4.

Material. Four specimens (1104, 1107–9). 1107 (Pl. 86, fig. 7) is part of a stem, with small, basally united leaves covering a node. It measures *c.* 1 cm. in width at the level of the sheath. Leaves are free above with pointed acuminate apices. On either side are some long, leaf-like branches, like those seen in some of the living species of *Equisetum*, but no nodes are visible in them.

1108 (Pl. 86, fig. 8) shows a node with six pocket-like depressions, each of which has a tooth-like projection representing the base of a lost leaf. It is estimated that there were about twelve leaves at the node. No surface features are visible.

1109 (Pl. 86, fig. 9) shows a minute shoot apex and the last two visible nodes of the stem. It measures *c.* 0·8 cm. in length, *c.* 1·5 mm. in width at the node, and *c.* 1 mm. at the internode. It is difficult to ascertain the number of leaves enveloping the apex of the stem.

1104 (Pl. 86, fig. 10) is a detached nodal diaphragm *c.* 7 mm. in diameter. The margin is fimbriated as in the specimen illustrated by Frenguelli (1944*c*, pl. 5). No other details are discernible.

Subdivision PTEROPSIDA
Class PTEROPHYTA
Order FILICALES
Family OSMUNDACEAE
Genus CLADOPHLEBIS Brongniart 1849

EXPLANATION OF PLATE 86

Figs. 1–3. *Thallites* sp. 1, 1104 *a*, *b*, ×1; 2, 3, the same, ×2·5.

Figs. 4–6. *Neocalamites carreri* (Zeill.) Halle. 4, 1095, indicating a node, and longitudinal ridges and furrows on the stem, ×1; 5, 1096, stem with a whorl of leaves at a node, ×1; 6, 1097, a nodal diaphragm, ×1.

Figs. 7–10. *Equisetites fertilis* Frenguelli. 7, 1107, a node with a whorl of leaves, ×1; 8, 1108, a node showing bases of leaves, ×1; 9, 1109, stem apex covered with young leaves, ×5; 10, 1104, a nodal diaphragm, ×10.

Fig. 11. *Cladophlebis kurtzi* Frenguelli. 1106, a pinna, ×1.

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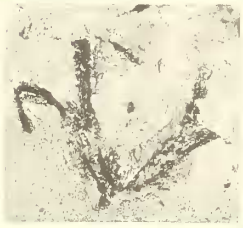

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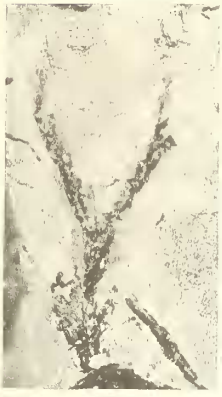

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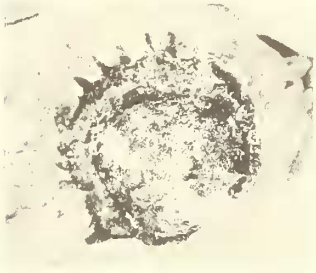

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Cladophlebis kurtzi Frenguelli

Plate 86, fig. 11; Plate 87, figs. 1, 2

1921 *Aspleuium whitbyense* Heer; Kurtz, pl. 16, figs. 202 *a*, *b*.
1927 *Cladophlebis uebensis* (Brongniart) Nath.; Du Toit, p. 321, fig. 2.
1947 *Cladophlebis kurtzi* Frenguelli, pp. 52–53, pl. 4, figs. 4–6; pl. 6, fig. 2 (?1).

Material. Three specimens (1059, 1060, 1116), consisting of a large number of frond fragments lying close to, and overlapping each other. The pinna rachis is conspicuous, with pinnules attached closely by broad bases. Pinnules are small, *c.* 1 cm. long and 5–6 mm. broad at the base, oblong with an entire margin and obtusely rounded apex. Sometimes pinnules are slightly curved distally. Each pinnule has a distinct mid rib, and fairly steep and close lateral veins. Each lateral vein forks once close to the mid rib, and again at half the distance between the mid rib and the margin of the pinnule. Near the margin, all the branches of the lateral veins are almost equidistant from each other.

Remarks. This species was earlier identified as *Asplenium C. whitbyense* (Kurtz 1921), and later as *C. nebensis* (Du Toit 1927), but it differs from both in essential details. In *C. nebensis* (Brongn.) Nath. the lateral viens are forked only once (Brongniart 1828, pl. 98, fig. 3), whereas in *C. kurtzi* the lateral veins normally fork twice.

Cladophlebis mesozoica Kurtz

Plate 87, figs. 3–6

1947 *Cladophlebis mesozoica* Kurtz; Frenguelli, pp. 59–60, pl. 6, fig. 5; pl. 7B.
1947 *Cladophlebis concinna* (Presl) Du Toit; Jones and de Jersey, p. 12, text-fig. 4 (pl. 1, fig. 4).

Material. Three specimens (1059, 1060, 1118). 1059 (Pl. 87, fig. 3) is a part of a bipinnate frond with a rachis *c.* 3 mm. thick, and bears two rows of opposite pinnae, each generally more than 7·5 cm. long. 1060 (Pl. 87, figs. 4, 5) shows a slender pinna rachis bearing distantly and alternately arranged pinnules. Each pinnule is attached by its broad base, measures *c.* 1·5 cm. in length, 8–9 mm. in width at the base, and has a more or less entire margin, and short acute apex. Further, each pinnule has a distinct mid rib with twice-forking, alternate lateral viens, the ultimate branches of the latter tending to become parallel toward the margin.

Remarks. There is a superficial resemblance between this species and *C. kurtzi*, but a closer study indicates that *C. mesozoica* differs in having distantly and alternately arranged pinnules with acute apices, as opposed to the closely and oppositely arranged pinnules with obtuse apices in *C. kurtzi*.

Similar specimens illustrated by Jones and de Jersey (1947) were erroneously compared with *Cladophlebis concinna* (Presl) Du Toit (1927, p. 318, pl. 17, fig. 1). The latter species differs from *C. mesozoica* in having almost overlapping leaflets with rounded apices, and typically once-forked lateral veins.

Cladophlebis johnstoni Walkom

Plate 87, figs. 7, 8

1925*a* *Cladophlebis johnstoni* Walkom, p. 76, figs. 2, 2*a*.

1947 *Cladophlebis mendozaensis* Geinitz; Frenguelli, pp. 60–63, pl. 8B; pl. 9, figs. 2, 3 (others?); pl. 10, figs. 1–3, 8 (others?); pl. 11; pl. 12, figs. (1–3?).

Material. Two specimens (1057, 1111). 1111 (Pl. 87, figs. 7, 8) shows the terminal part of a frond with pinnae varying in length from less than 0·5 cm. at the apex, to 2·3 cm. at the base, and with entire to broadly crenate margins. Lateral veins fork one to three times. Each lobe of a pinna has an independent set of veins, indicating the equivalence of a lobe to a pinnule.

Remarks. Frenguelli (1947) had referred many specimens of this species to *C. mendozaensis*, a species based primarily on a very fragmentary specimen described and poorly illustrated by Geinitz (1876, pl. 2, fig. 4). The latter differs from *C. johnstoni* in most of the structural details of the pinnule, such as shape, margin, and venation.

Cladophlebis australis (Morris) Seward

Plate 88, figs. 1–4; Plate 89, fig. 11

Synonymy. See Frenguelli 1947, pp. 56, 57, pl. 2, figs. 8–10.

Material. Four specimens (1053, 1055, 1056, ?1117), showing a typical bipinnate frond with a stout rachis measuring up to 6 mm. in width. Pinnae are alternate, forming angles of about 50° with the rachis. Pinnules are alternate to sub-opposite, lanceolate, and attached to the pinna rachis by the whole base. Each pinnule has a broad base, entire or slightly undulate margin, shortly acute or sometimes more or less truncate apex, up to 2·5 cm. in length, and 0·6 cm. in width at the base. The mid rib of each pinnule tends to fade out towards the apex. Lateral veins arise at acute angles from the mid rib and typically fork twice, the ultimate branches tending to become parallel near the margin. In 1053 (Pl. 89, fig. 1) the shape and attachment of the pinnules appear a little different from those of the other specimens; however, venation appears to be essentially of the same type; it is only tentatively referred to this species.

EXPLANATION OF PLATE 87

Figs. 1, 2. *Cladophlebis kurtzi* Frenguelli. 1, 1115, fragments with closely set pinnules, ×1; 2, part of 1116 showing veins, ×2·5.

Figs. 3–6. *Cladophlebis mesozoica* Kurtz. 3, 1059, indicating part of a bipinnate frond, ×1; 4, 1060, showing shape and attachment of pinnules, ×1; 5, part of above showing venation, ×2·5; 6, 1118, a small pinna, ×1.

Figs. 7, 8. *Cladophlebis johnstoni* Walkom. 7, 1111, part of a frond, ×1; 8, part of above showing veins, ×2·5.

EXPLANATION OF PLATE 88

Figs. 1–4. *Cladophlebis australis* (Morris) Seward. 1, 1055, part of a bipinnate frond, ×1; 2, part of above showing veins, ×2·5; 3, 1117 indicating shape of pinnules, ×1; 4, 1056, apical part of a pinna, ×1; 4, 1056, apical part of a pinna, ×1.

Figs. 5, 6. *Cladophlebis sp.* 5, 1112, ×1; 6, 1113, ×1.

EXPLANATION OF PLATE 89

Fig. 1. *Cladophlebis sp.* 1053, ×1.

Figs. 2, 3. *Cladophlebis wielandi* sp. nov. 2, 1054, parts of two pinnae, ×1; 3, part of above showing venation, ×2·5.

Figs. 4, 5. *Sagenopteris longicaulis* Du Toit. 4, 1137*a*, a more or less complete leaflet, ×1; 5, parts of leaflets with details, ×2·5.

Fig. 6. *Dicroidium odontopteroides* (Morris) Gothan. 1051, distal part of a forked frond, ×0·5.

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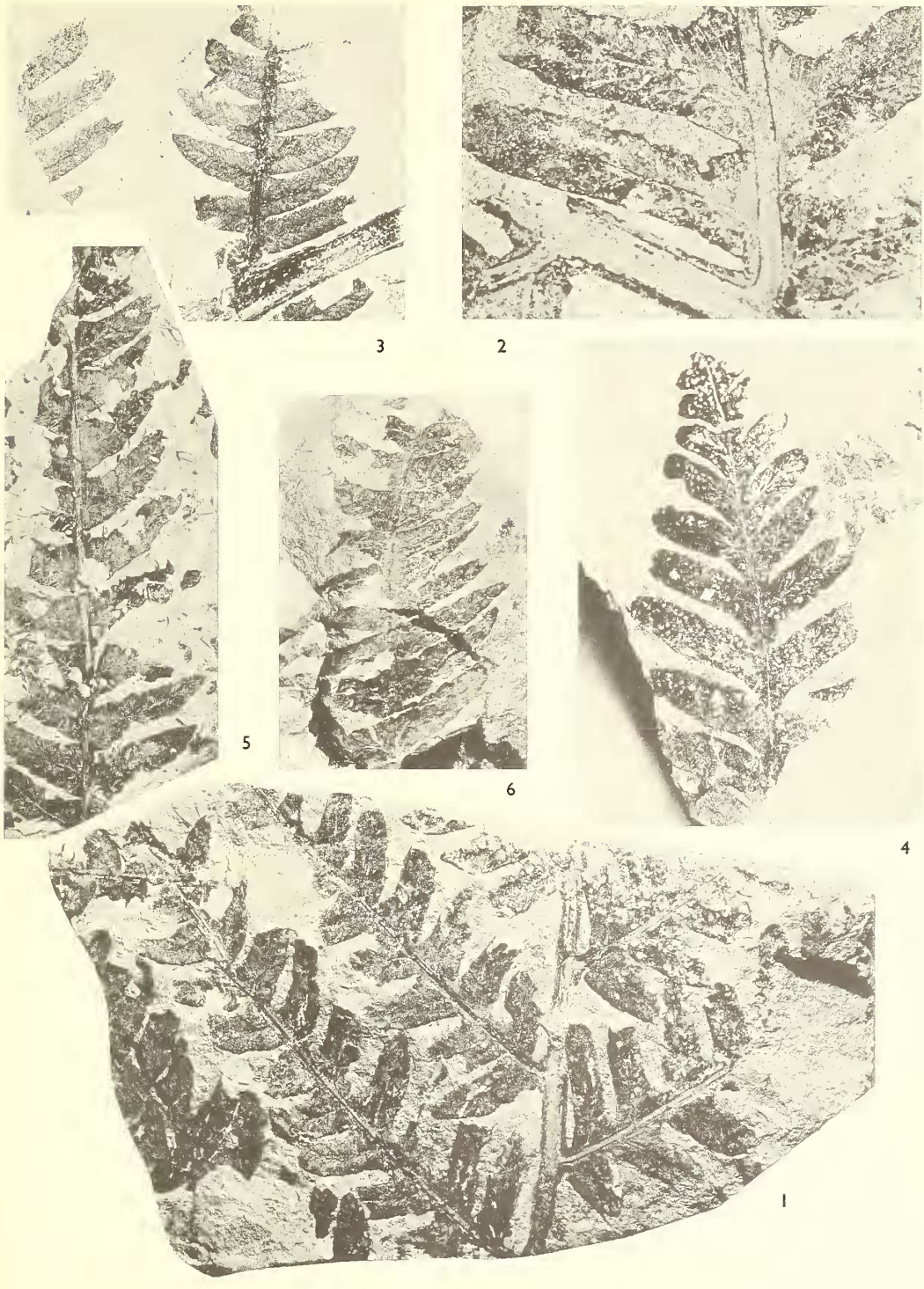

JAIN and DELEVORYAS, Middle Triassic flora, Argentina

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2

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4

JAIN and DELEVORYAS, Middle Triassic flora, Argentina

Cladophlebis wielandi sp. nov.

Plate 89, figs. 2, 3

1947 *Cladophlebis concinna* (Presl) Du Toit; Jones and de Jersey, p. 12, text-fig. 5, pl. 1, fig. 4?

Holotype. 1054 (Pl. 89, figs. 2, 3).

Material. Holotype only, showing two pinnae of a frond, probably still connected with the rachis (but not exposed by preparation because of other overlying significant specimens). Preservation good, with excellent details of pinnule venation.

Diagnosis. Leaf bipinnate, pinnules alternate to sub-opposite, fairly closely spaced, attached to the pinna rachis at angles of about 70°, *c.* 1·5 cm. in length, oblong–lanceolate with serrate margin, and acute apex; mid vein of each pinnule forked at the apex; lateral veins few, typically forked only once, rarely with a second dichotomy in one of the branches of the lateral veins.

Remarks. This species is closely associated with *Cladophlebis mesozoica* Kurtz, but it differs from the latter in having closely spaced pinnules with serrate margins, and a once-forking system of lateral veins, as opposed to the widely spaced alternate pinnules with almost entire margins and typically twice-forked lateral veins in *C. mesozoica* Kurtz.

The new species, however, shows some resemblance to *C. denticulata* (Brongn.) Fontaine, and *C. sewardi* Johansson. It is similar to *C. denticulata* in having pinnules with serrate margins and once-forking lateral veins, but differs in having shorter pinnules, a less acute apex, and fewer veins.

There is a greater resemblance between this species and *C. sewardi* (Johansson 1922, pl. 1, fig. 42), but it differs from the latter in lacking the regular second dichotomy of the lateral veins.

Cladophlebis sp. indet.

Specimen 1112 (Pl. 88, fig. 5) shows either the subterminal portion of a frond or part of a pinna of a large bipinnate frond. The rachis is *c.* 1 mm. in width, and has opposite to sub-opposite pinnules arranged in two rows. Pinnules are somewhat curved distally, up to 2 cm. in length and 7 mm. in width at the base. Each pinnule is lanceolate with a crenate margin and acute apex. Veins are poorly preserved.

This specimen appears similar to one of Frenguelli's specimens (Frenguell 1947, pl. 9, fig. 5) referred to *Cladophlebis mendozaensis*, but it is hard to justify its identification with that species. It may be an ill-preserved specimen of *C. johnstoni*.

Specimen 1113 (Pl. 88, fig. 6) is similar to 1112, but the pinnules appear to be more slender in form and attached at wider angles. It may be related to one of the species described above, but superficially it resembles *C. integra* (Oishi and Tanah) Frenguelli (Frenguelli 1947, p. 35, fig. 21), and *C. indica* (Oldh. and Morris) Feistmantel (Oldham and Morris 1862, pl. 27, fig. 2).

Class CAYTONIALES

Genus SAGENOPTERIS Presl 1838

Sagenopteris longicaulis Du Toit 1927

Plate 89, figs. 4, 5

Material. Overlapping fragments of one or more specimens collectively numbered as 1137*a–d*. Because of crowding, precise outline of individual leaflets is not clear. Each leaflet is *c.* 6 cm. in length, and has

a distinct mid rib and many lateral veins, the latter forming angles of about 65° with the mid rib. Lateral veins are a little less than 1 mm. apart and start branching and anastomosing freely only a short distance from the mid rib.

Class CYCADOPHYTA
Order PTERIDOSPERMALES
Family?
Genus THINNFELDIA Ettingshausen 1852

Thinnfeldia dutoiti sp. nov.

Plate 90, fig. 4

1927 *Thinnfeldia rhomboidalis* Ettings.; Du Toit, p. 340, text-fig. 6c.

Holotype. 1046 (Pl. 90, fig. 4).

Material. Holotype only, measuring *c.* 8 cm. in length.

Diagnosis. Leaves pinnate (as far as known); rachis slender; pinnules widely spaced, alternate to sub-opposite, attached by their whole bases, rhombic with more or less acute apices; four or more veins entering each pinnule, each vein forking once or twice.

Remarks. Thinnfeldia dutoiti differs from *T. rhomboidalis* Ettings. in having less slender leaflets, lacking a thickened margin and distinct mid rib. Townrow (1957) has also indicated that these species are different from each other.

Townrow (1957) is openly suspicious about the existence of *Thinnfeldia* in the Mesozoic floras of the Southern Hemisphere. All the specimens hitherto known from Gondwanaland, and earlier referred to this genus, probably belong to *Dicroidium* Gothan. But in the absence of any indication of dichotomy of the fronds, this species is referred to *Thinnfeldia.*

Thinnfeldia praecordillarae Frenguelli (1944*c*)

Plate 90, figs. 7, 8

Material. Two specimens (1044, 1052). 1052 is *c.* 8 cm. in length. It has a distinct rachis bearing two rows of pinnules; the pinnules are alternate, small, up to 5 mm. in length, and elliptical in shape. Each pinnule has a small mid rib, which gives off a number of small simple (all?) radiating veins. 1044 (Pl. 90, fig. 8) has more or less semicircular pinnules.

EXPLANATION OF PLATE 90

Figs. 1–3. *Dicroidium odontopteroides* (Morris) Gothan. 1, 1048, showing veins in some pinnules, ×1; 2, 1047, showing lanceolate pinnules with characteristic venation, ×1; 3, 1088, basal part of a forked frond, ×1.

Fig. 4. *Thinnfeldia dutoiti* sp. nov. 1046, ×1.

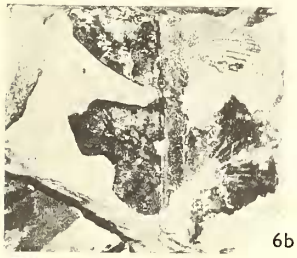
Figs. 5, 6. *Dicroidium feistmanteli* (Johnston) Gothan. 5, 1045, with veins in parts of some pinnules ×1. 6*a*, 1050; 6*b*, 1119; 6*c*, 1049; three fragments of fronds, ×1.

Figs. 7, 8. *Thinnfeldia praecordillarae* Frenguelli. 7, 1052, showing smaller and oblong pinnules, ×1; 8, 1044, with larger and semicircular pinnules with distinct mid ribs, ×1.

Figs. 9, 10, 14–16. *Incertae sedis.* 9, 1128, ×1; 10, 1129, ×1; 14, 1130, ×1; 15, 1136, ×3; 16, 1101, ×1.

Figs. 11–13. *Fanerotheca extans* Frengeulli. 11, 1099, ×4; 12, 13, printed from Wieland's photographic negatives, magnification unknown.


6a


6b


6c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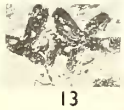
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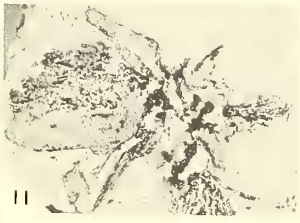
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Remarks. Some specimens figured by Walkom (1928, pl. 26, figs. 1, 2) from the Esk district of Queensland were described by him as fertile specimens of *Todites williamsoni.* However, neither in the description nor in the illustrations is there any convincing evidence of this. If that is the case, they do not appear to be different from the present material of this species.

Family CORYSTOSPERMACEAE
Genus DICROIDIUM Gothan 1912

Dicroidium odontopteroides (Morris) Gothan

Plate 89, fig. 6; Plate 90, figs. 1–3

Synonymy. See Townrow 1957, pp. 33–39.

Material. Four poorly preserved specimens (1047–8, 1051, 1088). 1051 (Pl. 89, fig. 6) shows distal part of a forked frond, each half up to 13 cm. in length with an axis *c.* 2 mm. wide. Pinnules are sub-opposite, smaller in size near the base and apex, and larger between. The largest pinnule is *c.* 2·5 cm. in length, and 0·5 cm. in width at the base. Each pinnule is attached to the rachis by its whole broad base, and has an entire margin, and shortly acute apex. The veins are not visible. Venation, visible in 1048 (Pl. 90, fig. 1) and 1047 (Pl. 90, fig. 2) is typically without a mid rib. In 1047 the pinnules are lanceolate. In 1088 (Pl. 90, fig. 3) the pinnules appear as lobes of an undivided lamina.

Remarks. All the specimens described are either small fragments or are very badly preserved. However, together they justify their inclusion in this species. But for the merger of *Dicroidium lancifolium* in *D. odontopteroides* (Townrow 1957), some of the specimens could certainly be identified with *D. lancifolium.*

Dicroidium feistmanteli (Johnston) Gothan

Plate 90, figs. 5, 6

Synonymy. See Townrow 1957, p. 39.

Material. Four specimens (1045, 1049–50, 1119) showing fragments of fronds with closely arranged sub-opposite pinnules on a rachis. The pinnules are rather expanded, broader distally than at the base. There is no mid rib, and all the veins tend to converge toward the base, but they do not meet at the same point.

Remarks. The specimens could almost as well be referred to *Dicroidium* (*Zuberia*) *zuberi* (Szajnocha) Townrow (1957). Although it is difficult to distinguish between the leaves of these two species, Townrow (1957) declined to express any opinion about this species, presumably because of its reported association with peculiar fructifications that are never found associated with *D. feistmanteli.* Because no such fructifications occur in association with the leaves described above, it is reasonably safe to refer these specimens to *D. feistmanteli.*

Also, without cuticles it is difficult to distinguish between *Dicroidium* and *Hoegnia* (Townrow 1957), and none occurs.

Dicroidium coriacium (Johnston) Townrow

Plate 91, figs. 1, 2

Synonymy. See Townrow 1957, p. 45.

Material. Five poorly preserved specimens (1908–93), up to 10 cm. in length, and forking once at some distance (about one-third of the length of the leaf) above the base. The margin varies from entire to broadly crenate, even in the same leaf. Each marginal projection (Pl. 91, fig. 2) represents an unseparated pinnule with 2–3 veins arising jointly from the mid rib far below the projection of the margin. The distance between two marginal projections represents the length of a pinnule.

Remarks. This species was first described and illustrated by Johnston (1887; 1888, pl. 26), and subsequently by Walkom (1925*a*, pp. 79–81, figs. 6–8). Townrow (1957) was doubtful about the propriety of referring two specimens, represented by Walkom's figs. 6 and 7, to this species, apparently because of some differences in the outline of the leaves. However, it is apparent from the specimens described above that the margins may vary even in the same leaf, and there is no doubt that Walkom's three specimens belong to this species.

Geinitz (1876, p. 6, pl. 2, figs. 7, 8) described the species *Pachypteris stelzneriana*, which Frenguelli (1941*a*) later redescribed as *D. stelznerianum*. Geinitz's drawings suggest that it is distinct from *D. coriacium*, but subsequent illustrations and a restoration of this species by Frenguelli (1941*a*) make it impossible to distinguish it from *D. coriacium*. If Frenguelli correctly identified his specimens with Geinitz's then the two species are in reality one.

Genus PTERUCHUS Thomas 1933

Pteruchus rhaetica (Geinitz) comb. nov.

Plate 90, fig. 15

1876 *Sphenolepis rhaetica* Geinitz, p. 12, pl. 2, figs. 23, 24.
1903 *Stachyopitys sp.*, Seward, pp. 66, 67, pl. 9, figs. 1, 2.

Material. A single specimen (1136) consisting of a large number of microsporangiate (?) appendages arranged in fertile heads of *c.* 5 mm. in diameter. Stalks are not visible in the specimen, but the presence of more than one fertile head is clearly indicated.

Remarks. The specimen described above is specifically identical with *Sphenolepis rhaetica* Geinitz, whatever it may be. Geinitz (1876) had considered these fossils as spherical or compressed cones bearing numerous spirally arranged obovate woody scales. Seward (1903) considered them as male flowers. Although no spores have been recovered from the specimen, it seems to be an organ similar to microsporangiate structures described by Thomas (1933) as a species of *Pteruchus* Thomas.

Pteruchus is a pollen-bearing genus reminiscent of *Crossotheca*, a Palaeozoic pteridosperm microsporangiate structure (Delevoryas 1962, p. 123). Apparently similar Mesozoic microsporangiate fructifications have been referred to *Antholithus* (Antevs 1914) and *Stachyopitys* (Shirley 1898; Seward 1903), but these genera either lack a precise definition or include more than one natural group of plants (Thomas 1933). *Pteruchus*, on the other hand, is a precisely defined genus of Corystospermaceae, a family of Southern

EXPLANATION OF PLATE 91

Figs. 1, 2. *Dicroidium coriacium* (Johnston) Townrow. 1, 1089, almost three complete fronds, ×1; 2, 1090, distal part of a frond with crenate margin, ×1.

Figs. 3–7. *Xylopteris rigida* (Dun) comb. nov. 3, 1070, showing greater part of a frond, ×1; 4, 1078, frond with closely arranged pinnules, ×1; 5, 1075, ×1; 6, 1126, indicating half a frond with distantly arranged pinnules, ×1; 7, 1077, a smaller frond, ×1.

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Hemisphere pteridospermous plants. Therefore, the specimen described above is referred to this genus.

Genus FERUGLIOA Frenguelli 1944*b*

Feruglioa samaroides Frenguelli (1944*b*)

Plate 97, figs. 15–19

Material. Two specimens (1064, 1105). 1064 (Pl. 97, figs. 15–17) measures *c.* 5·5 mm. in length and in width. It matches Frenguelli's specimen closely except that at the distal end it is apparently less cordate in shape, and the bifid micropyle is not as evident as in Frenguelli's specimen. The central line is also not very clear. The wing-like extensions are clearly seen.

1105 (Pl. 97, figs, 18, 19) is *c.* 6 mm. in length, and 4 mm. in breadth. It has a long distal prolongation, but the bifid nature of the micropyle is not evident. Wings are masked by the dark colour of the specimen; the central line is quite distinct.

Genus XYLOPTERIS Frenguelli 1943*a*

Xylopteris rigida (Dun) comb. nov.

1889 *Sphenopteris elongata* Carruthers; Szajnocha, pp. 223, 224, pl. 2, fig. 2.
1903 *Stenopteris elongata* (Carruthers) Seward, p. 70, pl. 7, fig. 2; pl. 11, fig. 3.
1909 *Stenopteris rigida* Dun, p. 313, pl. 50, figs. 1, 2.
1917*a* *Stenopteris elongata* (Carruthers) Walkom, p. 40, pl. 1, fig. 1; pl. 6, fig. 2.
1933 *Stenopteris densifolia* Thomas, p. 247, fig. 51.
1943*b* *Xylopteris elongata* (Carruthers) Frenguelli, pp. 324, 325, figs. 30, 31.
1951 *Xylopteris elongata* (Carruthers) Frenguelli; Menendez, pp. 224–6, pl. 15, figs. 9, 11.

Material. Ten fairly well-preserved specimens (1063, 1070–3, 1075–9, 1102). The largest is *c.* 10 cm. in length and no stalk is present in any. Typically, the main axis of each frond is forked once; each half regularly bears alternate to sub-opposite, simple, linear pinnae. Each pinna is *c.* 1 mm. broad, has a lamina with an entire margin, and, like the rachis, a single vein which terminates within a small rounded obtuse apex. The pinnae are spaced *c.* 0·5–1 cm. apart.

Remarks. This species has often been confused with *X. elongata* (Carruthers) Frenguelli (Carruthers 1872; Frenguelli 1943*b*). The latter has forked fronds, which are irregularly pinnate and have simple, forked, or more divided pinnae, often all on the same frond. *X. rigida*, on the other hand, has only simple and regularly arranged pinnae.

Further, it is difficult to distinguish between this species and *Xylopteris argentina* (Kurtz) Frenguelli (1943*b*). The latter is a rather ill-defined species based on some fragmentary specimens illustrated by Kurtz (1921, pl. 16, figs. 200–2). All these fragments may belong to *X. elongata* (Carruthers) Frenguelli, *X. rigida* (Dun) comb. nov., or *Sphenobaiera tenuifolia* (Johnston) comb. nov. (described later).

Considering the range of variation in size and spacing of the pinnae in *X. rigida*, it also becomes difficult to separate this species from *X. densifolia* (Du Toit) Frenguelli (Du Toit 1927, p. 364, text-fig. 13; Thomas 1933, text-fig. 51; Frenguelli 1943*b*).

Genus FANEROTHECA Frenguelli 1944*a*

Fanerotheca extans Frenguelli (1944*b*)

Plate 90, figs. 11–13

Material. A single specimen (1099, Pl. 90, fig. 12) having the appearance of a small flower-like structure

with four or more appendages terminating a small stalk. The terminal part of this fructification is *c.* 1 cm. in diameter. Also included in this species are specimens illustrated in Pl. 90, figs. 12, 13, printed from the old negatives left by Wieland, and for which the original specimens are no longer available.

Order CYCADEOIDALES, Family?
Genus YABEIELLA Oishi 1931

Yabeiella wielandi Oishi

Plate 92, figs. 1–7

1921 Un-named specimens, Kurtz, pl. 21, figs. 187, 190, 191, and the un-numbered figure to the left of 187.
1929 Un-named specimen, Wieland, p. 447, leaf in fig. 5*a*.
1931 *Yabeiella wielandi* Oishi, pp. 263, 264.
1943*a* *Yabeiella brackebushiana* (Kurtz) Oishi; Frenguelli, pl. 2, fig. 4.
1947 *Yabeiella brackebushiana* (Kurtz) Oishi; Jones and de Jersey, pp. 50, 51, text-figs. 43, 45.

Material. Five specimens (1008?, 1026–8, 1030). Holotype (1026, Pl. 92, figs. 1–2) is *c.* 3·1 cm. in length, 0·8 cm. in width. The margin, as in all other specimens of this genus, is entire. It has parallel sides and an obtusely rounded apex. Lateral veins form angles of about 65° with the mid rib. Some of the lateral veins fork once at varying distances from the mid rib, while some unite with the adjoining ones. Near the margin of the leaf there are about 18 lateral veins per cm., and all of them join the marginal veins. In 1027 (Pl. 92, fig. 3) the apex of the leaf is more or less acute. 1028 (Pl. 92, figs. 4, 5) has a narrower form, *c.* 5·5 mm. in width. 1008 (Pl. 92, figs. 6, 7) is the largest specimen, *c.* 8·8 cm. in length, but having much fewer and steeper lateral veins (about 11–13 per cm. along the margin, and forming angles of about 45° with the mid rib); no cross connexions between the veins are visible; the general form of the leaf is like that of the other specimens, but this specimen is only tentatively assigned to the species.

Remarks. There is a considerable range of variation in form and venation of the leaf. Further, although a large number of specimens have been assigned to this species, nothing is known about the base of the leaf.

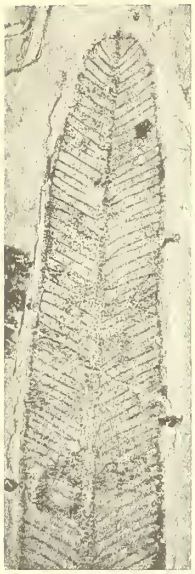
Jones and de Jersey (1947) are of the opinion that this species is indistinguishable from *Yabeiella brackebushiana*, and that the specimens referred to it show secondary veins identical with those of *Y. brackebushiana*; however, the leaves have rounded apices, and have parallel edges, in contrast to the acute apex and lanceolate form of the latter. Further, they think that Kurtz's specimens demonstrate a gradation in the acuteness of the apices and in the form of the leaves.

On the contrary, *Y. wielandi* is easily distinguishable from *Y. brackebushiana*, even if the apices are not quite rounded in the former. There is a consistent difference in the shape and in the lateral veins of the leaves of the two species, and there is no indication that the specimens are fragments of compound leaves. All the available specimens strongly indicate that they are fragments or whole specimens of simple leaves.

EXPLANATION OF PLATE 92

Figs. 1–7. *Yabeiella wielandi* Oishi. 1, 1026, holotype, also with the holotype of *Fraxinopsis major* Wieland, ×1; 2, holotype, showing details, ×2·5; 3, 1027, a fragment with more or less acute apex, ×1; 4, 1028, a narrower form of leaf, ×1; 5, same, showing details, ×2·5; 6, 1008, leaf with fewer and steeper veins, ×1; 7, same, showing details, ×2·5.

Figs. 8–14. *Yabeiella spatulata* Oishi. 8, 1062, ×1; 9, same, showing details, ×2·5; 10, 1021, a small complete leaf, ×1; 11, 1022, ×1; 12, same, showing details, ×2·5; 13, part of 1019 showing veins, ×2·5; 14, 1032, basal part of a leaf, ×1.



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Yabeiella spatulata Oishi

Plate 92, figs. 8–14

1931 *Yabeiella spatulata* Oishi, p. 264, pl. 26, figs. 2, 2*a*.
1947 *Yabeiella brackebushiana* (Kurtz) Oishi; Jones and de Jersey, text-figs. 43, 46.

Material. Eight specimens (1018–23, 1031, 1062), up to 6·5 cm. in length, and 7 mm. in width at the apex. The leaf is shortly petiolate to sub-sessile at the base, and gradually wider toward the apex (being more so in smaller or younger specimens). When present, the apex appears to be emarginate. The mid rib is characteristically stout up to the apex, longitudinally striated, and minutely pitted. The lateral veins form angles of about 55–65° with the mid rib, fork once at some distance from the mid rib (a few unite with the adjoining ones), and number 11–14 per cm. along the margin of the leaf before they unite with the marginal vein.

Remarks. Oishi (1931) founded this species on a single specimen from the Triassic of Argentina, in which the leaf has a broad, rounded apex. In the specimens described above, only two show apices, which are emarginate. An emarginate apex may be a character of the species, or it may result from some injury while the leaf was young; therefore, this character alone is insufficient to assign these specimens to a new species. All other characters are identical with the previously known characters of this species.

Yabeiella brackebushiana (Kurtz) Oishi

Plate 93, figs. 1–5

1921 *Oleandridium brackebushianum* Kurtz, pl. 18, fig. 307; pl. 21, figs. 147–50, 302, 304–6 (also un-named figs. in same plate, 145, 310, 312).
1927 *Taeniopteris* cf. *brackebushiana* (Kurtz) Du Toit, p. 354, text-fig. 2.
1931 *Yabeiella brackebushiana* (Kurtz) Oishi, p. 263, pl. 26, figs. 3, 5, 6.

Material. Three specimens (1007, 1009, 1029), up to 12 cm. in length, and 1·6 cm. in width in the middle. The mid rib is thick at the base, becoming gradually narrow above. Lateral veins form angles of 60–70° with the mid rib (angles being smaller at the apex and the base). Only a few veins are seen to bifurcate once and unite with the adjacent veins at different distances away from the mid rib. There are about 20 veins per cm. along the margin.

Remarks. Y. brackebushiana is a species with rather variable characters. It includes leaves with acute to acuminate apices, veins ranging from 14–20 per cm. along the margin, and forming angles of 50–70° with the mid rib. The specimens described above are similar to Kurtz's figs. 145, 308, and 312.

Yabeiella crassa Jones and de Jersey

Plate 93, figs. 6–13

1947 *Yabeiella crassa* Jones and de Jersey, pp. 53, 54, text-fig. 48, fig. 5 (only).

Material. Four specimens (1011, 1013 *a*, *b*, 1016), up to 7 cm. in length, and up to 1·6 cm. in width. The leaf has sub-sessile base, and narrowly obtuse apex. Mid rib is generally thick and distinctly striated, *c.* 2 mm. toward the base. Lateral veins form angles of about 65° with the mid rib, being somewhat steeper toward the apex, and number about 14 per cm. along the margin. Forking and union of veins are rare.

Remarks. The specimens generally agree with those of Jones and de Jersey (1947), who